Gentleman's Bay Walkway

for

Auckland Council

Supplementary Report on Geotechnical Conditions

REV A

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COASTAL MANAGEMENT AND ENGINEERING

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1.0 Introduction

The Auckland Council are looking to re-establish the pedestrian connection to Gentleman's Bay from Waitara Road and have prepared a concept design. The shoreline is subject to coastal erosion and the Council are seeking advice on the likely effects of erosion on the design of the walkway. Davis Coastal Consultants prepared a report in October 2014 commenting on coastal processes and making an assessment of an appropriate access route. The report provided a concept design that required remediation of the existing slip primarily by providing subsoil and surface stormwater drainage. The report noted that further Geotechnical investigation would be required to quantify the risks. In November 2014 the Council instructed that further work be undertaken such that a factor of safety could be established on the proposed concept remedial scheme.

*1.1 Location**

Gentleman's Bay is located at the coastal edge of the suburb of St Heliers, Auckland, halfway between Achilles Point and West Tamaki Point (Figure 1.1a). The proposed walkway is located entirely on land that is unformed road (Waitara Road and Glendowie Road) (Figure 1.1b), and is located at 1766680 East and 5920620 North on the New Zealand Transverse Mercator projection.

Figure 1.1a: Location of Gentleman's Bay within wider Auckland setting

* Location information has been set out in the earlier report but is included here as it is often useful for reference in discussion.

Figure 1.1b: Location of proposed walkway at seaward end of Waitara Road / Glendowie Road

1.2 Further Investigation Undertaken

Four additional Boreholes, shear vane and penetrometer readings were made on site by specialist Geotechnical Engineers, KGA Geotechnical. Their report is appended.

From the combined site investigation information a soils model was established and slope stability calculated. Factors of Safety were calculated for various scenarios with;

Factor of Safety (FOS)	Condition
1.0	Slope about to fail
1.2	Recommended minimum for Parks and Bush Reserve
1.5*	Recommended minimum for Residential Subdivision

*More detail on FOS given in section 2.2 below

The model was calibrated such that the existing saturated condition provides a FOS of 0.9 which is consistent with the failed slope.

2.0 Results

2.1 Load Cases

The soils model was tested for four cases to represent the different conditions of the existing and concept slope.

- As existing
- With drainage as proposed
- With a re-profiled slope and thinner soil layer and the proposed drainage
- Under Earthquake conditions

2.1.1 As Existing

The as existing analyses assume the ground surface in its current state and saturated ground conditions. As we know the slope is failing under these conditions a Factor of Safety (FOS) of less than 1 (0.9) was attributed to help calibrate the soils model.

2.1.2 With Proposed Drainage

This case assumed drainage similar to that proposed in our earlier report and indicated a FOS of 1.2. Such a FOS is indicated as acceptable but less than ideal see section 3 below.

2.1.3 With Proposed Drainage and a Re-Profiled slope

This is similar to the case above but included additional regrading of the soil slope to ensure a maximum reduced 1.8m depth of soil. The model indicated negligible change to the factor of safety as a result of this work. The result confirms that the primary issue to address is the water infiltration into the slope , both surface and ground water. In reality, regrading of the surface will be required to ensure surface water drains off and the slope can remain unsaturated.

2.1.4 Seismic Loading

The design case is to assume a 150 year return earthquake. The slope was found to fail in this event. Importantly, the slope was also checked for stability under smaller earthquakes. Loads associated with a 50 year or 100 year earthquake were also modelled with the slope showing unacceptable FOS (FOS<1.0) in all cases. The model indicates that even with the proposed works the slope will fail if subject to earthquake loads.

2.2 *Summary of Results*

The results of the modelling are presented in Table 2 of KGA Geotechnical report of 1 December 2014 and reproduced below.

Case	Factor of Safety	Comment
As Existing (Current Ground water level)	0.9	Failing - unacceptable
Lowered Groundwater (As concept proposal)	1.2	Acceptable*
Lowered Groundwater with re-profiled surface	1.2	Acceptable*
Seismic - 1 in 150 year (0.7% chance of occurring in any year)	0.8	Failing - unacceptable

*For context of "Acceptable" see Section 2.3

2.3 *Context for Results*

The Auckland Council provides minimum Geotechnical requirements for soils within the area in the *Auckland Council - Code of Practice for Land Development and Subdivision*. The document sets minimum limits depending on the importance of the land being considered, the likelihood of risk and severity of consequence. Table 2.C.1 from the *Code of Practice*, setting out the requirements, has been reproduced as Table 2.3.1 below.

Residential subdivision or development has the minimum requirement for a Factor of Safety of 1.5. This is reduced for short term cases such as elevated water table or a seismic event to a Factor of Safety of 1.3 and 1.2 respectively.

"Parks and Bush Reserve Land" are treated as low risk areas with an acceptable normal Factor of Safety specified at 1.2. Saturated and Seismic conditions are both required to have a Factor of Safety of 1.1

It would be desirable for the works to achieve a FOS in excess of 1.5 for all states but it would seem acceptable to meet the requirements set out in the *Code of Practice* for "Parks and Bush Land".

Table 2.C.1 Factors of Safety

I. Residential Subdivision/Development	
	Factor of Safety (FoS)
Normal ground water condition	1.5
Extreme (worst credible) groundwater condition	1.3
Seismic condition with 150 yr event	1.2
II. Low risk areas such as Parks and Bush Reserve Land	
	Factor of Safety (FoS)
Normal ground water condition	1.2
Extreme saturated condition	1.1
Seismic condition with 150 yr event	1.1
III. High Risk Areas that may result in loss of life/ national interest	
i. Refer to the appropriate legislations/guidelines where applicable e.g. TP109/NZSOLD for dams where the return period used is pmf	
ii. A FOS > 1.5 may be required for categories that include essential utility services and infrastructures that have been identified as critical by Civil Defence.	
iii. Discussion with Council engineers to establish an agreed FoS	

Table 2.3.1

The model indicated following the proposed work that the drained slope achieved a FOS of 1.2 which is considered acceptable by the *Code of Practice*. With the drainage provided the slope is designed not to become saturated so that that case is not relevant unless the drainage fails.

Under a seismic event (earthquake) the slope is unstable, it does not achieve the Code recommended Factors of Safety and does not even achieve unity. The model indicates therefore, that in the event of an earthquake the slope will become unstable and is likely to slip again. The design earthquake proposed the *Code of Practice* is a 150 year event (0.7% chance of occurring in any year). Lesser, more frequent events, 100 year and 50 year events (1% and 2% chance of occurrence in a year), were also modelled and also indicated slope failure.

The conclusion from this is that even with the proposed remedial work <u>there is a very high probability that the slope will fail if an earthquake occurs</u>.

The *Code of Practice* provides a Risk Matrix which is reproduced as Table 2.3.2 below. It suggests that on high risk slopes, following geotechnical engineering, risks may remain higher than normally acceptable. In such a case information is attached to the property title (Section 36 of the Building Act) allowing Land Owners to make an informed decision about purchasing or developing the Land. This would typically be on the advice of the Geotechnical Engineer

The Council is the Land Owner in this situation and must therefore make the decision on whether it is acceptable to proceed with development of the land.

	Instability	Instability	development	Investigation
Very High	Evidence of active or historic instability – landslide or rock face failure, extensive instability may occur within site or beyond site boundaries	High risk of loss of life. Catastrophic or extensive significant damage or economic loss	Unsuitable for development unless major geotechnical work can satisfactorily improve stability. Risk after development may be higher than normally accepted (includes Section 36(2))	Extensive geotechnical investigation required
High	Evidence of active creep, ancient instability, potentially progressive/regressive/ minor slips or minor rock face instability, significant instability may occur during and after extreme climatic conditions and may extend beyond the site boundaries	Low risk of loss of life. Significant damage or economic loss	Development restrictions and/or geotechnical works required. Risk after development may be higher than normally accepted (may include Section 36(2))	Engineering Geological assessment, drilling investigation required
Medium	Evidence of possible soil creep or a steep soil covered slope; significant instability can be expected if the development does not have due regard for the site conditions	Virtually nil risk of loss of life. Moderate damage and economic loss	Development restrictions may be required. Engineering practices suitable to hillside construction necessary. Risk after development generally no higher than normally accepted	Visual assessment. Hand an d possible drill investigation methods
Low	No evidence of instability observed; instability not expected unless major site changes occur	Minor damage, limited to site unless major development occurs	Good engineering practices suitable for hillside construction required. Risk after development normally acceptable	Visual assessment. Possible hand investigation methods
Very Low	Typically shallow soil cover with flat to gently sloping topography	Virtually nil	Good engineering practices should be followed	Visual assessment

* Taken from Crawford and Millar Paper dated 1998 titled "The Design of Permanent Slopes for residential Developments. Table 1."

Table 2.3.2 Risk Classification Guideline

3.0 Discussion

3.1 Consequences

With any geotechnical remediation there is ongoing risk of slope failure following the works. In this particular case there is a very high chance of slope failure if the drainage works fail or an earthquake occurs. Well designed drainage works should not fail and periodic monitoring can improve the confidence in the operational system. It is likely that an earthquake will occur within the design life of any structures placed on the slope that will cause slope failure. It is also likely that minor creep will occur within the slope so that structures would need to be detailed to account for this. In particular, the storm water system designed to take surface water from above the slope would need to well below any slip surface and is best located within the "hard" Waitemata series sandstones underlying the site.

If remedial works do not proceed the slope will continue to fail. The slip is likely undergo large scale movements under heavy rain/saturated soils conditions. The entire slip area is likely to progressively slump onto the foreshore and this could be in marked events depositing very large volumes of soil onto the foreshore. Within 1-5 years the majority of the slipped mass could have been deposited. There are obvious implication on the environment of this and possible risks of severe injury if the area is still being frequented.

Areas uphill of the slip area are also prone to slumping, particularly if they were to become saturated and/or lose vegetative cover. This uphill instability is likely to be exacerbated by the ongoing movement of the existing slip area.

The option to "Do Nothing" therefore also has potential negative consequences. As a minimum minor works to prevent the ongoing saturation of the slope should be considered. Such minimum works could include

- redirection of the existing stormwater by capture in a flexible flume or similar
- drainage around the existing scarp
- re-contouring the surface to facilitate run off and close large cracks.

It must be considered whether, if slope and access improvement were to occur, this is introducing people to risk. The slope is unacceptably unstable in the event of an earthquake and so it may be reasonable to assume that not providing access is avoiding risk. We note that the area is frequented by visitors at present with anecdotal reports of many visitors cars parked in the adjacent street. It is our opinion therefore that people are already visiting the location and any upgrade to the slope that improves slope stability is likely to decrease risk of harm.

3.2 Budget Cost

Further investigation has indicated that if stormwater is to be piped under the slip as proposed it would be deeper and is likely to require directional drilling. This will increase the cost and preliminary budget estimates previously provided may underestimate the final costs of slope remediation. We note that during informal discussion a view was expressed that it was a project costing in excess of $300,000 (plus professional costs etc). This cost has not been verified but suggests there is a risk for the required budget to increase.

3.3 Recommendation

There is likelihood even with the proposed works that the slope will fail if there is an earthquake. If works proceed, any amenity works should be kept as low impact and low cost as practicable. In our opinion, the land is not geotechnically suitable for development.

There are also serious consequences of inaction and it is our recommendation that at least minimal works are under taken to divert water from the slope and close the surface.

The extent of minimal works is then a budgetary decision for the Council depending on available funds and a decision taken in the knowledge there is a risk of future instability. The addition of pedestrian access in some form if only by forming a path is a relatively small additional cost and access should be improved when any remedial works are done. The success of the remedial works could be monitored for a period before access is further improved.

We recommend such stabilisation works as are financially viable, with a minimum of removing stormwater discharging to the top of the slope and closing the surface of the slope to water entry and planting with a fast growing vegetative cover. Minor re-contouring to improve access should be undertaken as part of this if practicable. This access improvement should be viewed as short term and "disposable".

We recommend fuller stabilisation works as per the original concept if this is viable but note that the Council must accept such works will be lost in the event of an earthquake.

Appendix A
Specialist Geotechnical Report